REMARKS

Claims 1-2 and 5-27 are pending in this application, of which claim 1 has been amended. No new claims have been added.

Claim 1 stands objected for an informality which has been corrected in the aforementioned amendments.

Claim 12 stands rejected under 35 USC §102(b) as anticipated by Ganapathy, S.; Zhang, X.Q.; Uesugi, K.; Kumang, H.; Suemune, I.; Kim, B.J.; Seong, T.Y.; "Effect of GaNAs Strain Compensating Layer Over InAs Quantum Dots Grown By MOMBE," Indium Phosphide and Related Materials Conference, 2002. IPRM 14th, 12-16 May 2002; ppg: 557-560 (hereinafter "**Ganapathy et al.**").

The Examiner urges:

> Ganapathy anticipates a semiconductor optical device having quantum dots with tensile strain, provided by tensile strained GaNAs capped layer, and quantum dots with compressive strain, InAs QDs, ABSTRACT.

Applicants respectfully disagree. Page 559, lines 6-8 disclose:

> This is an experimental evidence that the compressive strain produced by the InAs QDs tends to degrade the QD optical properties and the strain accumulation will be compensated by the tensile stain in the GaNAs SCL.

Although it is admitted that the InAs QDs (Quantum Dots) are in compressive strain, there is no disclosure in **Ganapathy et al**. that the GaNAs SCL (Strain Compensating Layer) contains quantum dots under tensile strain.

More specifically, as can be seen from Gallium Nitride (GaN), I SEMICONDUCTORS AND SEMIMETALS, Pankove, Jacques I. and Moustakas, Theodore D., Academic Press, pps. 176-177, attached hereto, the lattice constant of GaN is 4.52, the lattice constant of GaAs is 5.653, and the lattice constant of InAs is 6.058.

GaNAs is a mixed crystal of GaN and GaAs, and has a lattice constant somewhere between the lattice constants of each. Therefore, the GaNAs capping layer has a smaller lattice constant then the GaAs substrate. Thus, the GaNAs capping layer receives tensile stress from the substrate ("Tensile strained GaNAs"). "Tensile strained GaNAs" has no relation to the InAs quantum dots. InAs quantum dots have a larger lattice constant than the GaAs substrate (and the GaNAs capping layer). Therefore, the InAs quantum dots receive compressive stress from the substrate ("Compressive strain formed due to InAs QDs"). There are no quantum dots with tensile strain.

If InGaAs is used for the capping layer (ABSTRACT), it will necessarily have a greater lattice constant than the GaAs substrate, and therefore receive a compressive stress from the GaAs substrate. Then, the two compressive stresses on the substrate are additive. Reversing the sign of one stress will keep the total strain of the system to a minimum.

Thus, the 35 USC §102(b) rejection should be withdrawn.

The Examiner has indicated that claims 1-11 would be allowed if claim 1 were amended to overcome the informality objection, and claims 13-27 have been allowed. Claim 1 has been so amended.

In view of the aforementioned amendments and accompanying remarks, claims 1-2 and 5-27, as amended, are in condition for allowance, which action, at an early date, is requested.

If, for any reason, it is felt that this application is not now in condition for allowance, the Examiner is requested to contact Applicants' undersigned attorney at the telephone number indicated below to arrange for an interview to expedite the disposition of this case.

In the event that this paper is not timely filed, Applicants respectfully petition for an appropriate extension of time. Please charge any fees for such an extension of time and any other fees which may be due with respect to this paper, to Deposit Account No. 01-2340.

Respectfully submitted,

ARMSTRONG, KRATZ, QUINTOS,
HANSON & BROOKS, LLP
William L. Brooks
Attorney for Applicant
Reg. No. 34,129

WLB/mla
Atty. Docket No. **031022**
Suite 1000
1725 K Street, N.W.
Washington, D.C. 20006
(202) 659-2930

23850
PATENT TRADEMARK OFFICE

Enclosures: copy of "Gallium Nitride (GaN) I Semiconductors and Semimetals"

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Semiconductors and Semimetals

A Treatise

Edited by *R. K. Willardson*
Consulting Physicist
Spokane, Washington

Eicke R. Weber
Department of Materials Science
and Mineral Engineering
University of California at
Berkeley

Gallium Nitride (GaN) I

SEMICONDUCTORS
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Volume 50

Volume Editors

JACQUES I. PANKOVE
ASTRALUX INC., BOULDER, COLORADO AND
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
UNIVERSITY OF COLORADO
BOULDER, COLORADO

THEODORE D. MOUSTAKAS
DEPARTMENT OF ELECTRICAL ENGINEERING
BOSTON UNIVERSITY
BOSTON, MASSACHUSETTS

ACADEMIC PRESS
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TABLE IV

SOME PROPERTIES OF InN

Wurtzite Polytype		
Bandgap energy (eV)	1.89[a]	
Lattice constants (nm)	0.3533...0.3548 (a)[b]	0.5963...0.5760 (c)[b]
Thermal expansion (K^{-1})	$2.7 \ldots 3.7 \cdot 10^{-6}$ ($\alpha_{\parallel}$)[c]	$3.4 \ldots 5.7 \cdot 10^{-6}$ ($\alpha_{\perp}$)[c]
Thermal conductivity ($W\,cm^{-1}\,K^{-1}$)	0.8[d]	
Melting point (K)	2146[e]	

[a]Zetterstrom, 1970.
[b]See Tansley and Foley, 1986; Wakabara and Yoshida, 1989.
[c]Madelung (ed.), 1982.
[d]Slack et al., 1987.
[e]van Vechten, 1973.

not as outstanding as those of AlN. Preparation of InN is thus considered to be of scientific interest rather than technological importance. Note, however, that for obtaining blue light emission from nitride based structures, a significant amount (40–50%) must be alloyed into GaN. Pure InN has not yet been grown as single crystal by any growth technique, rather, fine grained polycrystalline layers are obtained. The dissociation temperature of InN is approximately 500°C (Trainor and Rose, 1974) and nonstoichiometry at temperatures required for crystallization severely affects the quality of these InN samples. No accurate measurements exist for either the lattice constants or the mechanical and thermal properties. Values given in Table IV serve as a rough guideline only.

4. NITRIDES WITH ZINC-BLENDE STRUCTURE

Zinc-blende III–V nitrides have been synthesized by heteroepitaxy on cubic substrates, such as Si, GaAs, MgO, and cubic 3C-SiC. All these substrates share the handicap of a very large lattice mismatch to the nitrides. Only a few groups have succeeded in growing zinc-blende nitrides and have reported measurements of fundamental structure properties of these cubic layers. Lattice constants reported so far are compiled in Table V. Measurements of other mechanical and thermal properties are still lacking.

Cubic AlN has been prepared by epitaxial growth on Si substrates using pulsed laser ablation (Lin *et al.*, 1995a) and by solid-phase epitaxy between Al and TiN (Petrov *et al.*, 1992), respectively. The lattice constant

TABLE V

PROPERTIES OF ZINC-BLENDE NITRIDES

Zinc-blende Polytype	AlN	GaN	InN
Bandgap energy (eV)	5.11[c]	3.2–3.3[b]	2.2[a]
Lattice constant (nm)	0.43(8)[d]	0.452[e]	0.49(8)[f]
Thermal expansion	—	—	—
Thermal conductivity	—	—	—

[a]Lamprecht and Segall, 1991.
[b]Lei et al., 1991.
[c]Jenkins, Hong, and Dow, 1987.
[d]Petrov et al., 1992.
[e]Strite et al., 1991.
[f]Strite et al., 1993.

is measured to be $a = 0.438$ nm for a thin film by applying electron diffraction.

Zinc-blende GaN has been synthesized by several groups (Mitzuta *et al.*, 1986; Paisley *et al.*, 1989; Lei *et al.*, 1991, 1992; Strite *et al.*, 1991; Powell *et al.*, 1993; Kuwano *et al.*, 1994; Lin *et al.*, 1995b) on different substrates. An average lattice parameter of 0.452 nm fits the reported values within experimental errors. The structural quality of layers was found to be poor. A rough substrate/epilayer interface, high density of planar defects, and the tendency of phase transformation into the wurtzite structure are reported to be the basic problems. Also, the optical quality of zinc-blende GaN cannot compete with that of wurtzite GaN because only broad and weak emission is detected which is quenched already at low temperatures (Ramirez-Flores *et al.*, 1994). Recently, however, progress has been made in understanding the nucleation stage of GaN on GaAs (Yang *et al.*, 1996; Brandt *et al.*, 1996) resulting in a much improved interface and a higher crystal perfection (Trampert *et al.*, 1997). These results will be discussed in a later section of this chapter. The optical quality of these samples, which exhibit intense luminescence at room temperature and above, give rise to the hope that zinc-blende nitrides may eventually mature (Yang, Brandt, and Ploog, 1996; Brandt *et al.*, 1997).

Strite *et al.* (1993) reported the existence of a zinc-blende InN polytype prepared by molecular beam epitaxy (MBE). The lattice constant $a = 0.498 \pm 0.001$ nm was measured by X-ray diffraction. TEM microstructural analysis revealed a high density of stacking faults from which wurtzite domains were nucleated. Abernathy and MacKenzie (1995) obtained InN